CONDUCTING POWER FOR HEAT OF CERTAIN ROCKS*

A collection of more than twenty specimens of rocks of the best marked descriptions were chosen for the purpose, and were cut to a uniform shape and size by Messrs. Walker, Emley, and Beall, of Newcastle-on-Tyne, and a part of them were subjected to experiment. The plates are circular, 5 in. in diameter, and half-an-inch thick, and they are as smoothly and accurately ground to this uniform size as was possible in the case of some of the refractory substances as granite, whinstone, &c., that were employed. On the other hand, many more friable and softer rocks, as chalk, coal, marl, &c., are not included in the list of sample sections now collected.

The purpose of the present paper is simply to establish from the experiments the general *bad* conducting powers of the harder rocks, and to corroborate in the case of a few examples that were numerically reduced the conclusions of a similar kind that were obtained by Peclet.

The rock-plate to be tested is placed on a flat-topped tin boiler of its own diameter to raise its temperature on the underside to the boiling-point of water, while on its upper side a conical flat-bottomed tin flask of spring-cold water is placed, and absorbs the heat transmitted through the rock section from its heated side. A thermometer inserted through a cork in this flask marks the rise of temperature and the quantity of heat transmitted through the rock.

A small quantity of heat is also intercepted and absorbed by it which requires a part of the higher temperature on the heated side to introduce it into the rock, but this quantity is so small compared to the quantity which passes through it and enters the water, that it may easily be allowed for by a suitable correction.

The flask above the rock contained about ½ lb. of water, and under the action of the steam heat below, it rose in temperature about 1° in 35 seconds for *slate*, and 1° F. in 38 or 40 seconds for different kinds of hard and close-grained rocks, as granite, serpentine, marble, and sandstone; while the time occupied for a similar rise in temperature was greatest in the case of a specimen of black shale from the coal-measures round Newcastle, when the thermometer rose 1° in 48 or 50 seconds, or *slower than* in the case of slate in the proportion of about 5 : 8.

In this series of trials it was easily supposed that the real temperature of the surfaces of the rock-plates was considerably different from those of the metallic surfaces in contact with them; and a thermo-electric pair of wires attached to cork-faces was now applied to test the real difference of temperatures of the two faces of the rocks. Two platinum wires were twisted on to the two ends of a piece of iron wire and were connected with the poles of a Thomson's reflective galvanometer. The iron wire itself was bent so as to bring its two twisted ends into contact with the opposite faces of the rock. On testing the thermo-electric arrangement by means of a double tin lid placed between its cork-faces, filled with water of different degrees of temperature on its two sides (which were measured by thermometers inserted in the lids), it was found that a difference of between 3° and 4° F. produced a deflection of 1 division of the galvanometer.

On now taking a plate of marble out of the heating vessel and placing it between the thermopyles, it was found that no sensible heat difference was recorded by it; the rock was reversed, top for bottom between its poles, and the effect was still insensible, although the heat of the finger pressing alone on one of the wire junctions moved the galvanometer 3° or 4°. In order to increase the temperature difference the rock-plate was then brought into contact with the metal surfaces by means of mercury; and the thermometric flask itself being filled with about 10 lbs. of mercury instead of ½ lb. of water, it was found that the thermometer rose 1° in 10 seconds, corresponding to a transmission of 330 heat units per hour through a standard plate 1 in. thick, and 1 square foot in surface. When taken out of its cell and transferred to the galvanometer, the temperature difference was now found to be about 7°; giving the rate of conduction about 47 heat units per hour, instead of between 22 and 28 heat units as assigned by Peclet.

The process of lifting the rock out of its cell having undoubtedly produced a loss of the heat difference before the measurement was made; a new mode was' now employed, and the wire junctions were pressed against the rock faces *in situ*, being at the same time protected from the heat of the boiler and thermometer plates facing opposite to them by thick felt wads upon which they were fastened to those plates. In this case a very different variation between the two rock-faces was now found the difference in the case of marble being 50° or thereabouts, while the passage of heat into the water thermometer flask was now about 264 heat units per hour, corresponding to a conducting power of about 5¼ heat units per hour. The same process was applied to two kinds of the black shale already described, and their conducting power was found to be much less than that of the fine-grained marble specimen, being at the rate of only 2 or 2½ heat units per hour. These quantities are not more than ⅕th or ⅙th part of the values obtained by Peclet for the same kinds of rocks. Although time did not permit these experiments to be repeated with a different arrangement of the apparatus, when the sources of error peculiar to each of them would have been easily removed, as their origin in each case is easily explained, yet they confirm provisionally the values of the thermal conductivities found by Peclet; since in two experiments which certainly gave the values alternately in excess and defect, the quantities obtained varied from 5 or 7 to 42 or 47 heat units per hour for a kind of marble to which Peclet assigns 22 or 28 heat units per hour as its conducting power; and in the case of some other rocks of which Peclet describes the conductivity as about half that of the close-grained marble just mentioned, the values found by experiment also indicate a smaller thermal conductivity of these rocks in almost exactly the proportion which Peclet has assigned.

The form in which it will be desirable to repeat these experiments is one which will show the amount and kind of influence exercised by junctions between the surfaces of solid, liquid, and gaseous bodies in retarding the transmission of heat across them; as well as to conclude the actual thermal conductivities of the materials employed, and for this purpose a suitable modification of the apparatus and of the mode of conducting the experiments has been contrived, which it may be expected will fully effect the objects which it is thus intended to obtain.

THE DIVERTICULUM OF THE SMALL INTESTINE CONSIDERED AS A RUDIMENTARY STRUCTURE*

THE author took this structure as an illustration in reply to those who are not yet satisfied that structures exist which are useless to the animal body containing them. Referring first to the case of the appendix vermiformis of the great intestine, a survey of the anatomy of the cæcum in various animals, and of the stages of its development in man, leads to the inference that this worm-like appendage is a rudimentary and virtually a useless structure. It has, however, been generally supposed that, being present, it must have some function; and as it was manifest that a thing of this kind at the otherwise closed end of the great intestine is a source of danger by admitting foreign bodies which it could not expel, it has been argued that contrivances designed to avert this danger might be recognised. That it opens at the back instead of at the bottom of the cæcum; that its opening is oblique; that it has a kind of valve; that it is directed more or less upwards; and so on. On the contrary, the worm-like appendix is a vestige, the rudimentary representative of the true cæcum, and all these supposed contrivances by which the danger is lessened are simply the result of the forward and downward development of the great intestine away from the resisting wall of the abdominal cavity against which the appendix and back of the intestine lie. Although from this cause the appendix vermiformis is not nearly so dangerous a structure as it might have been, it is, notwithstanding, occasionally the cause of death. The author knew of several cases of this, and every experienced pathologist must have met with it. Foreign matters get impacted, causing ulceration, and perforation takes place, followed after a few hours by death.

The conclusion, however, that there are parts within the animal body which are useless, and worse than useless because dangerous, is so distasteful to the adherents of the extreme theological school that they will rather fall back on the bare possibility of some unknown function even for such a rudiment. The diverticulum of the small intestine may be employed here to complete the argument. Although in a classification of rudimentary

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* Paper read by A. S. Herschel, F.R.A.S., before the British Association, Bradford.

* Abstract of a paper read by Prof. Struthers, F.R.S.E., of Aberdeen, before the British Association, Bradford.

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structures they would be placed in different groups, the one being normal though often varying, the other only occasional, they are on the same footing for the purposes of this argument. It is known to be a vestige of the structure joining the intestine by which, at an early stage of the evolution of the animal frame, nourishment is introduced. All trace of it usually disappears, but occasionally part of it remains as a pouch opening from the small intestine. It has the usual coats of intestine, the inner coat presenting the same food-absorbing villi. It is therefore acting, but no one will argue that it is designed for use in those comparatively few persons who possess it. Unfortunately it is sometimes the cause of death. The author had met with cases of this, and it is well known to surgeons. It may be unable to expel its contents; or by adhering to a neighbouring part a noose is formed, a most dangerous condition, a sort of bowel-trap, through which a knuckle of intestine slips, and strangulation, followed by death, is the result. Here then we have an elaborate structure which is useless, or worse because dangerous. Were a railway contractor to leave open a siding which he had used in the construction of the line, the train might dash into it and a fatal accident result. This is exactly what is done when this diverticulum of the small intestine is left unclosed, and the fatal accident occasionally occurs. Were further illustration necessary we might refer to the fact of disease sometimes attacking that functionless structure the rudimentary breast in the male.

The consideration of such structures as the diverticulum may be said not to take us farther than to clear the ground, showing us that we have been on the wrong path. But a survey of rudimentary structures generally carries us farther. On the hypothesis of the independent origin of species they are unintelligible, while the hypothesis of evolution furnishes a clue to the whole. The facts of embryology, of palæontology, of rudimentary as well as developed structures are harmonised, and the whole present themselves as the result of the operation of a great law, the equivalent in the organic world of the law of gravitation in the inorganic. Although we do not as yet see so well how this biological law operates, the anatomist sees enough to make him feel that he is shut up to some form or other of the theory of evolution, and that the notion which we imbibed in our early years, and have long cherished, that so-called species arose independently of each other, must be a mistake.

The slow progress which this view has made in this country compared with Germany, the author attributed partly to the teleological bias which anatomy early received among us, but mainly to the fact that anatomy has been taught in the medical schools of this country for the most part as a mass of detail in its professional application, without reference to the ideas which it suggests when more widely and profoundly studied as a science.

SCIENTIFIC SERIALS

Ocean Highways, October.—The principal article in this month's number is one by Lieut. Salaverry, of the Peruvian Navy, on the "Navigation of the Upper Amazon and its Peruvian Tributaries," in which he gives some very interesting particulars of the measures that have been adopted by the Peruvian Government to open up and encourage the flow of commerce along the great fluvial highways which connect the rich provinces of the Andes with the Atlantic. The amount of work done by the Peruvian Government during the last few years in the exploration of the region with which the article is concerned is wonderful, and we are sure quite unknown even to many of those who take an interest in geographical discovery. Captain Davis contributes a second article on the *Challenger*, which is followed by one on the Pacific Railways of the South, *i.e.* the Southern United States. Two very interesting narratives are "A Visit to the Kuh-I-Khwajah in Sistan," the place mentioned being a remarkable hill to the west of Naseribad, the chief city of Sistan; and "A Visit to Kuloja," by Mr. Ashton Wentworth Dilke, the plain of Kuloja being "a continuation of the Seven Rivers country running up between the Ala Tau and Thian-Shan Mountains."—Mr. E. G. Ravenstein contributes a paper on "Elmina, and the Dutch Gold Coast;" which is followed by an article on the *Polaris*, the usual reviews, proceedings of societies, &c. There are Maps of the former Dutch Possessions on the Gold Coast, of the Amazonas in Peru, of the Pacific Railways of the South, and a Chart of the *Challenger's* course to the Cape de Verde Islands.

Bulletin de la Société Impériale des Naturalistes de Moscou, No. 3, 1872.—In a paper on tantalum, in this number, M. Herman describes five different combinations of the metal with oxygen, two only having been hitherto known.—There are several zoological and botanical lists,—M. Becker gives an account of beetles and flies met with on a journey to the Astrachan region; Mr. M'Lachlan gives drawings of some new species of Phryganides, and a Chrysopa, found in Finland and the Caucasus; M. Hochhuth enumerates the beetles of Kien and Volhynien, &c., while M. Lindemann furnishes a report on the formation of his herbarium.—M. Lubimoff's paper on a new theory of the field of vision and magnification of optical instruments, has been elsewhere noticed in our columns.

No. 4 (1872) commences with an interesting article, with illustrations, by M. Mayewski, on evolution of the barbules of *Begonia manicata*, showing the various stages from that of simple hairs consisting only of epidermic cells.—Some strictures on M. Lubimoff's views as to the field of vision are offered by M. Bredichin, who thinks the theory neither new nor exact.—M. Hochhuth continues his list of beetles (as also in the following number), and M. Kryloff describes some geological formations in the Government of Kostroma.—Dr. Dreschler communicates an account of a collection of mathematical and physical apparatus in Dresden: and the number concludes with a table of meteorological observation in Moscow, in 1872.

SOCIETIES AND ACADEMIES

LONDON

Royal Horticultural Society, Sept. 17.—General Meeting.—Mr. Henry Little in the chair.—The Rev. M. J. Berkeley called attention to some pears, part of which were cracked and small, while the rest were perfect. They had been taken from opposite sides of the same tree, and the difference was probably caused by injury from wind when in a young state.—Mr. Bull exhibited for the first time *Odontoglossum Roezlii*, a near ally of *O. vexillarium*, and which Prof. Reichenbach suggests may be a hybrid between that species and *O. Phalænopsis*.

Oct. 1.—General Meeting.—Mr. Henry Little in the chair.—The Rev. M J. Berkeley alluded to the numerous interesting and rare species of fungi which were exhibited. *Faxillus atro-tomentosus*, sent by the Rev. W. W. Newbould from Woburn; *Russula aurata*, by Miss Hubbard, from Horsham; *Hydnum squamosum*, new to Britain, from Somerset, by Mr. Aubrey Clark; *Cortinarius orellanus*, also new to Britain, from Epping Forest, by W. G. Smith, &c. Mr. Berkeley also referred to Schwendener's theory as to the nature of lichens. Bornet had recently published an admirable paper in support of the same views. He himself, however, was not convinced of their correctness. On the contrary he believed he had seen the gonidia of *Parmelia* originating from hyphæ within the cells of some drift wood from the Arctic regions. He also read a letter from Dr. Thwaites, of Ceylon, who thought that the symmetrical growth of the lichens was an argument against one portion being parasitic on the other.

PHILADELPHIA

Academy of Natural Sciences, June 10.—Dr. Ruschenberger, president, in the chair.—Mr. Gentry made the following remarks:—At the last meeting of the Academy, Mr. Meehan made some observations upon the peculiar structure of the flowers of *Pedicularis canadensis*, observing that he had vainly watched them during two seasons with the view of determining the manner in which they were fertilised. He further said that he had noticed that they received the attention of a species of humble-bee, for the sake of their honey, which, in order to accomplish its purpose, always bored a hole into the side of the tube. On Wednesday morning last, I visited a spot where the plants were growing luxuriantly, affording an interesting field for observation. It was not long before I observed a *Bombus terrestris* to alight upon the outer side of the tube of a flower, at a distance of three feet from me. At this distance it did seem as if the bee in order to obtain the honey which it secretes, produced a slit into the tube, as Mr. Meehan observed. But the movements of the bee being so quick, and the distance too great to judge accurately, I ap-

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